

**UNITED STATES AIR FORCE  
RESEARCH LABORATORY**

---

**MAGNIFICATION OF IMAGERY  
TO COMPENSATE FOR THE DECREASE  
IN PERCEIVED SIZE ASSOCIATED WITH  
A 28-INCH VIEWING DISTANCE**

**Byron J. Pierce**

Air Force Research Laboratory  
Warfighter Training Research Division  
6030 South Kent Street  
Mesa AZ 85212-6061

**George A. Geri**

Raytheon Training and Services  
6030 South Kent Street  
Mesa Az 85212-6061

**November 1999**

**20000711 094**

AIR FORCE MATERIEL COMMAND  
AIR FORCE RESEARCH LABORATORY  
HUMAN EFFECTIVENESS DIRECTORATE  
WARFIGHTER TRAINING RESEARCH DIVISION  
6030 South Kent Street  
Mesa AZ 85212-6061

Approved for public release; distribution is unlimited.

**DTIC QUALITY INSPECTED 4**

**NOTICE PAGE**

**Publication of this special report does not constitute approval or disapproval of the ideas or findings. It is published in the interest of scientific and technical information (STINFO) exchange.**

**Using Government drawings, specifications, or other data included in this document for any purpose other than Government-related procurement does not in any way obligate the US Government. The fact that the Government formulated or supplied the drawings, specifications, or other data, does not license the holder or any other person or corporation, or convey any rights or permission to manufacture, use, or sell any patented invention that may relate to them.**

**The Office of Public Affairs has reviewed this document, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.**

**This special report has been reviewed and is approved for publication.**

**BYRON J. PIERCE  
Project Scientist**

**DEE H. ANDREWS  
Technical Director**

**JERALD L. STRAW, Colonel, USAF  
Chief, Warfighter Training Research Division**

# REPORT DOCUMENTATION PAGE

*Form Approved  
OMB No. 0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)			2. REPORT DATE November 1999	3. REPORT TYPE AND DATES COVERED Final - October 1998 to October 1999
4. TITLE AND SUBTITLE  Magnification of Imagery to Compensate for the Decrease in Perceived Size Associated with a 28-inch Viewing Distance			5. FUNDING NUMBERS  C - F41624-97-D-5000 PE - 62205F PR - 1123 TA - B0 WU - 01	
6. AUTHOR(S)  Byron J. Pierce George A. Geri			8. PERFORMING ORGANIZATION REPORT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)  Air Force Research Laboratory, Human Effectiveness Directorate Warfighter Training Research Division 6030 South Kent Street, Bldg 561; Mesa AZ 85212-6061  Raytheon Training and Services Co.; 6030 South Kent Street; Mesa, AZ 85212-6061			10. SPONSORING/MONITORING AGENCY REPORT NUMBER  AFRL-HE-AZ-SR-1999-0007	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)  Air Force Research Laboratory Human Effectiveness Directorate Warfighter Training Research Division 6030 South Kent Street, Bldg 561 Mesa AZ 85212-6061			11. SUPPLEMENTARY NOTES  Air Force Research Laboratory Contract Monitor: Dr Byron J. Pierce, AFRL/HEA (480) 988-6561 X-219, DSN 474-6219	
12a. DISTRIBUTION/AVAILABILITY STATEMENT  Approved for public release; distribution is unlimited.			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words)  This report describes an experiment to compare the perceived size of collimated and uncollimated aircraft targets presented on typical flight simulator background imagery. It has recently been suggested that magnifying the size of imagery might improve the spatial detail of simulated targets. Such a magnification would also render uncollimated targets perceptually more similar in size to collimated targets. It has been questioned, however, whether a magnification using a viewing distance of 44 inches should be applied to a visual display system whose viewing distance is only 28 inches. The present experiment was performed to answer this question.				
14. SUBJECT TERMS Collimated targets; Displays; Flight simulators; Imagery; Size perception; Uncollimated targets; Visual display systems; Visual imagery			15. NUMBER OF PAGES 12	
16. PRICE CODE				
17. SECURITY CLASSIFICATION OF REPORT  UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE  UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT  UNCLASSIFIED	20. LIMITATION ABSTRACT  UL	

## **SPECIAL REPORT<sup>1</sup>**

### **MAGNIFICATION OF IMAGERY TO COMPENSATE FOR THE DECREASE IN PERCEIVED SIZE ASSOCIATED WITH A 28" VIEWING DISTANCE**

**Byron J. Pierce**

Air Force Research Laboratory

Warfighter Training Research Division  
Mesa, Arizona

**George A. Geri**

Visual Research Laboratory

Raytheon Training and Services Co.  
Mesa, Arizona

### **Introduction**

Pierce and Geri (1998) compared the perceived size of collimated and uncollimated aircraft targets presented on typical flight simulator background imagery. They concluded that uncollimated imagery must be magnified by about 15-30% in order for it to appear the same size as collimated (and by implication, real-world) imagery. Pierce and Geri used F-15C targets and a viewing distance of 44" to the uncollimated display.

It has recently been suggested that magnifying the size of imagery in the Boeing Visual Integrated Display System (VIDS) might improve the spatial detail of simulated targets. Such a magnification would also render uncollimated VIDS targets perceptually more similar in size to collimated targets. It has been questioned, however, whether the magnification estimated by Pierce and Geri (1998), using a viewing distance of 44", should be applied to the VIDS, whose viewing distance is only 28".

The present study was performed to answer this question. Observers estimated the size of uncollimated F-15C targets that perceptually matched the size of collimated targets. The uncollimated targets were presented at the VIDS viewing distance of 28".

### **Methods**

**Observers.** Ten pilots served as observers. The observers ranged in age from 27 to 49 years with a mean of 37.3 years. Flight experience ranged from 130 hours to 4000 hours with a mean of 2343 hours.

**Apparatus and Stimuli.** A diagram of the optical system used to display both the collimated and uncollimated imagery is shown in Fig. 1. The imagery of each channel was rear-projected onto rigid screens (Stewart Lumiglass 130). One image was viewed directly at a distance of 28" and thus served as the uncollimated image. The other image was reflected in a large spherical mirror and was effectively collimated. The sources for the collimated and uncollimated background images were Barco Model 808 CRT projectors, and the two images were superimposed using a large glass beamsplitter.

---

<sup>1</sup> Request for reprints and/or questions concerning the information contained in this note should be directed to Dr. Byron Pierce at AFRL/HEA, Mesa, AZ, 85212-0904. Phone (480) 988-6561 or DSN 474-6561. E-mail [byron.pierce@williams.af.mil](mailto:byron.pierce@williams.af.mil). This work was supported by USAF Contract F-41624-97-D-5000.

The background image used in both the formation flight (FF) and basic fighter maneuver (BFM) conditions is shown in Fig. 2a (the crosses shown in the figure are not relevant to the present study). High-resolution targets on 35 mm slides were superimposed on the background imagery in each channel. In one condition, the targets were chosen to represent F-15Cs flying in FF with the observer's aircraft (see Fig. 2b), at distances of 500, 2,000, 6,000, or 12,000 ft. In the other condition, the observers' viewed the target aircraft as it might appear during a defensive BFM engagement (see Fig. 2c) at distances of either 4,000 or 7,000 ft. Target aircraft were displayed above the horizon for all distances tested.

The F-15C models used to produce the target stimuli were obtained from Viewpoint Data Labs. The appropriate perspective for the models was generated using SoftImage-3D (Microsoft), and the model was scaled as required using Adobe Photoshop. The background imagery was obtained from a typical flight simulator database. Observers' head movements were minimized with a chin rest, and a two-button response box was used for data collection.

**Procedure.** Observers were first allowed to adapt for 4-5 min to the illumination in the experimental room. Each experimental trial began with a 4-second presentation of the collimated image (target + background). That image was extinguished and the uncollimated (real) image was then presented for 4 sec. Using a response switch, the observer indicated whether the uncollimated test target appeared larger or smaller than the collimated test target. If the observer responded "larger", the size of the uncollimated target was decreased on the next trial, whereas if the observer responded "smaller", it was increased. Data collection continued until eight response reversals were obtained after the observer's response stabilized. All six target images were tested in a single experimental session that lasted about 30 min.

In most cases, the mean of the eight target sizes corresponding to the response reversals was taken as an estimate of the uncollimated target size that matched a given collimated target size. A slightly modified procedure was used, however, to calculate the mean perceived size for observer MH under two conditions (FF12K' and BFM7K') in which her response staircase would have otherwise gone beyond the available stimulus set. For those two conditions, a mean was obtained by estimating the uncollimated image size to which this observer responded "larger" and "smaller" in approximately equal numbers. This technique may have resulted in, at most, a 4% underestimation in perceived size for the two data points in question.

## Results and Discussion

The results of the present study are summarized in Table 1. The table entries are the measured percentage differences in the perceived size of the real and collimated images. The percentage difference was calculated by taking the difference in size between the uncollimated image and the collimated image that it was found to match, and dividing that difference by the size of the collimated image. Thus, a positive entry in Table 1 indicates that a larger uncollimated image was required to match a given collimated image (i.e., the uncollimated image was perceived to be smaller than the corresponding collimated image). The data for both the FF and BFM conditions are also shown in graphical form in Figs. 3 and 4. The lower graph in each figure shows the percentage increase in perceived size, and hence reflect the data presented in Table 1. The horizontal dashed lines in each lower graph indicate the mean percentage increase

for each stimulus condition. The upper graphs in Figs. 3 and 4 show the actual difference in perceived size found for each observer under each stimulus condition.

For the FF condition, the magnitude of the perceived size difference between the collimated and uncollimated displays varied from about 12% for the 12K' condition to about 24% for the 6K' condition, with a mean over all distances of just over 19%. For the BFM condition, the perceived size difference was very close to 20% for both distances tested. Thus, the overall estimated difference in perceived size was about 20%.

There was generally good agreement among the perceived size increases across the various simulated distances (see third row from bottom of Table 1). The only possible exception was the estimate for the FF12K' condition, which represented the smallest simulated aircraft target. Although the estimate for this condition was less than the other conditions, the effect averaged about 12% and was in the same direction (i.e., the size of the real image target was increased to match that of the collimated). Overall then, it appears that any conclusions drawn as to the perceived size of targets viewed on a real display located at 28" from the pilot's viewpoint can be applied to all simulated targets within a range of about two miles.

The data of Table 1 and Figs. 3 and 4 also indicate that there are considerable individual differences among the perceived size data obtained from the ten pilots tested. As is shown in the table, the standard error of the mean (*sem*) is about 3.8 for the estimated increase in perceive size across the overall means of each of the ten observers (see rightmost two columns in Table 1).

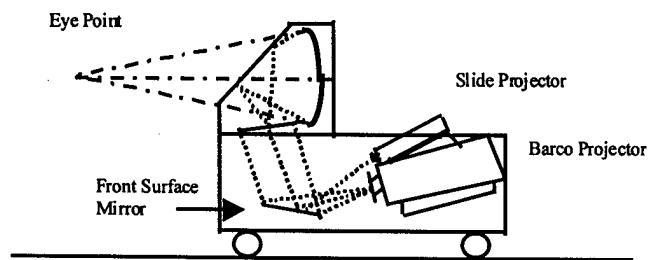
### Conclusions

The present data indicate that uncollimated VIDS imagery should be magnified by about 20% in order for it to appear the same size as collimated imagery. These data are in the range reported by Pierce and Geri (1998) for a longer real-image viewing distance.

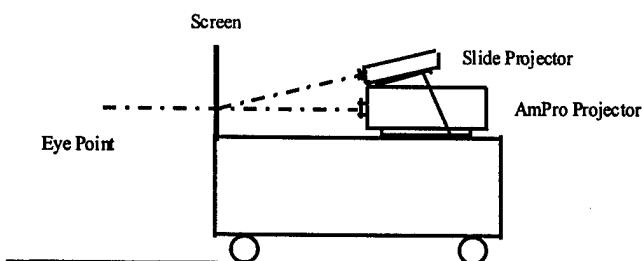
The present data also confirm the finding of Pierce and Geri (1998) that significant individual differences exist in perceived size estimates of this kind. We estimate the standard error of the mean for the perceived size estimates across observers to be about 3.8 suggesting that there is a 95% probability that estimates of the required magnification for real targets, obtained from the general population, will fall between about 10% and 30%.

### Reference

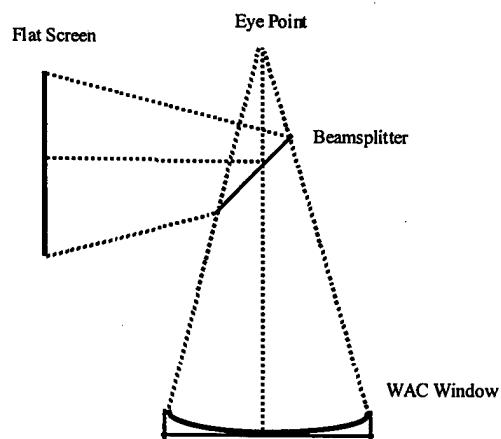
Pierce, B.J. and Geri, G.A. (1998). Display collimation and the perceived size of flight simulator imagery. *AFRL-HE-AZ-TR-1998-0058*, Warfighter Training Research Division, Air Force Research Laboratory, Mesa, Arizona.



a) Collimated-Image Projection System (WAC Window)

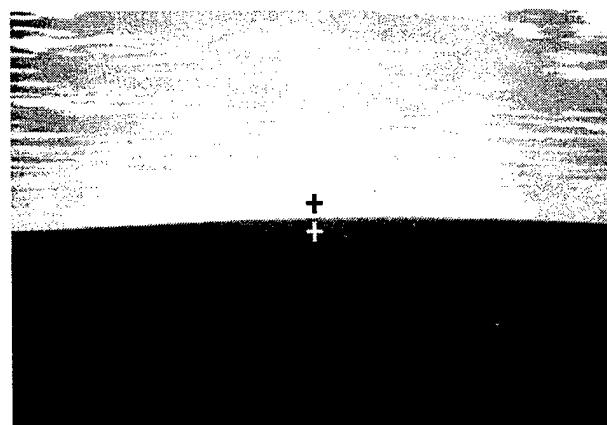


b) Real-Image Projection System

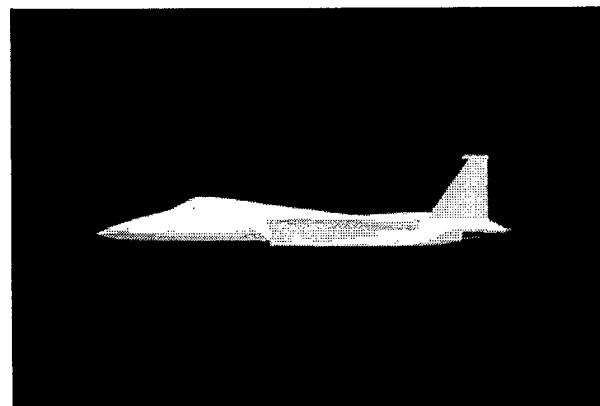


c) Top View of Combined Projection System

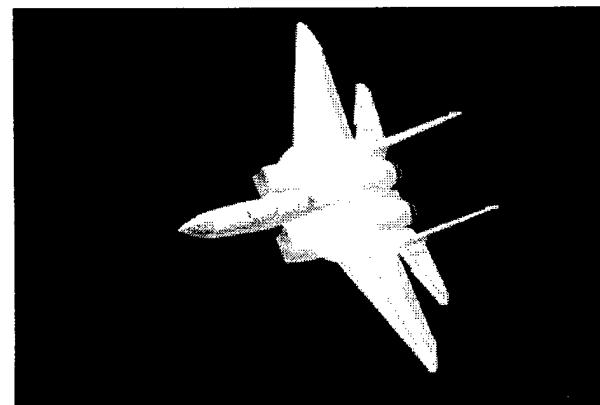
*Fig. 1. Diagrams of the Collimated and Real Components of the WAC/Real Display.*



(a) Background



(b) FF Target

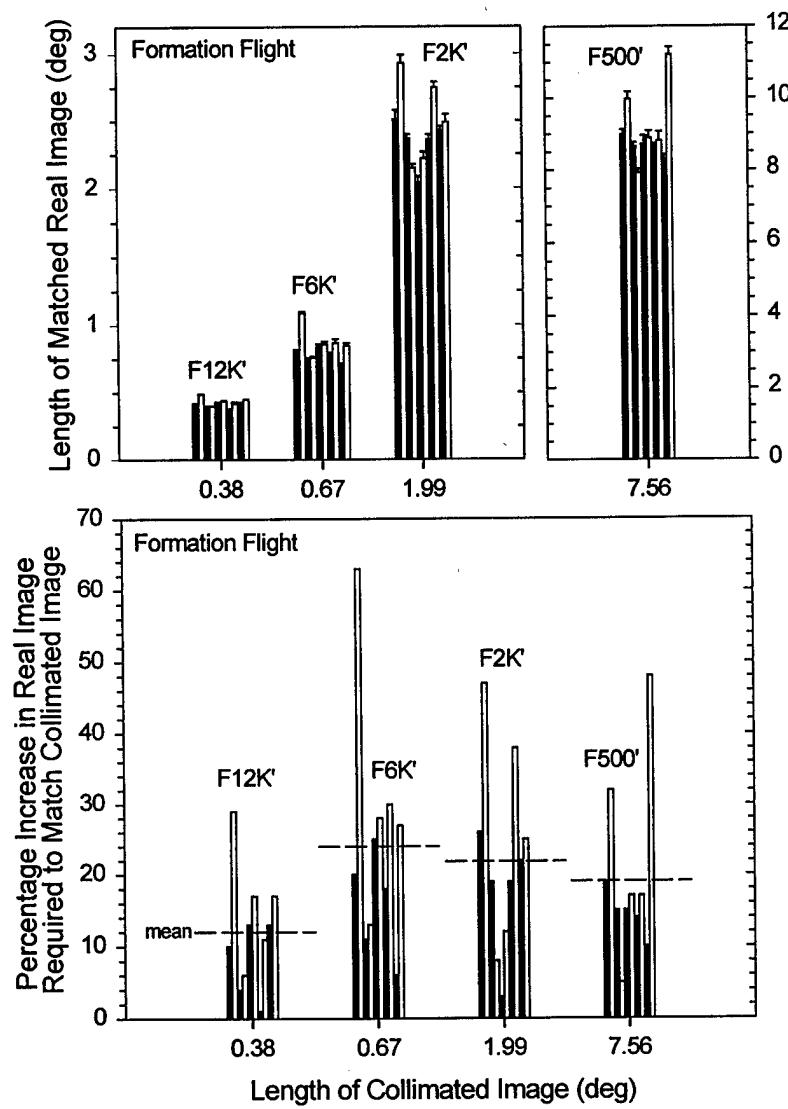


(c) BFM Target

*Fig. 2. Background Image and Target Stimuli.*

*Table 1 - Percentage Increase in Real Image Required to Match Collimated Image*

	Formation Flight				BFM		<i>mean</i>	<i>sem</i> (N=6)		
	12000'	6000'	2000'	500'	7000'	4000'				
RN	10.2	20.2	25.9	18.8	23.8	17.3	19.4	2.248		
MH	28.9	62.7	47.2	32.0	72.5	44.6	48.0	6.951		
RR	3.95	11.2	19.1	14.6	7.5	13.1	11.6	2.183		
CS	5.92	13.4	7.91	4.76	10.3	10.0	8.72	1.294		
MH	12.5	25.4	2.51	15.2	6.25	12.7	12.4	3.228		
SH	16.8	28.2	11.7	17.5	28.8	19.4	20.4	2.766		
GS	0.987	17.9	18.6	14.0	11.3	13.1	12.6	2.600		
SF	10.5	30.5	38.2	16.5	28.8	14.2	23.1	4.457		
DG	12.8	6.16	22.1	9.66	-3.13	13.7	10.2	3.440		
JG	17.1	27.4	24.9	48.2	17.8	43.3	29.8	5.341		
							<b><i>mean = 19.62</i></b>			
<i>mean</i>	11.97	24.30	21.81	19.12	20.39	20.14	<i>sem = 3.791</i>			
<i>sem</i>	2.504	4.962	4.249	3.915	6.649	4.052	<i>95% Conf. = +/- 9.70</i>			
<i>N</i>	10	10	10	10	10	10	<i>N = 10</i>			
<i>mean</i>	19.30				20.27					
<i>sem</i>	2.062				3.789					
<i>N</i>	40				20					
<i>mean</i>	19.62									
<i>sem</i>	1.85									
<i>N</i>	60									



*Fig. 3. Data for Each Observer Obtained at Each of the Four FF Distances.*

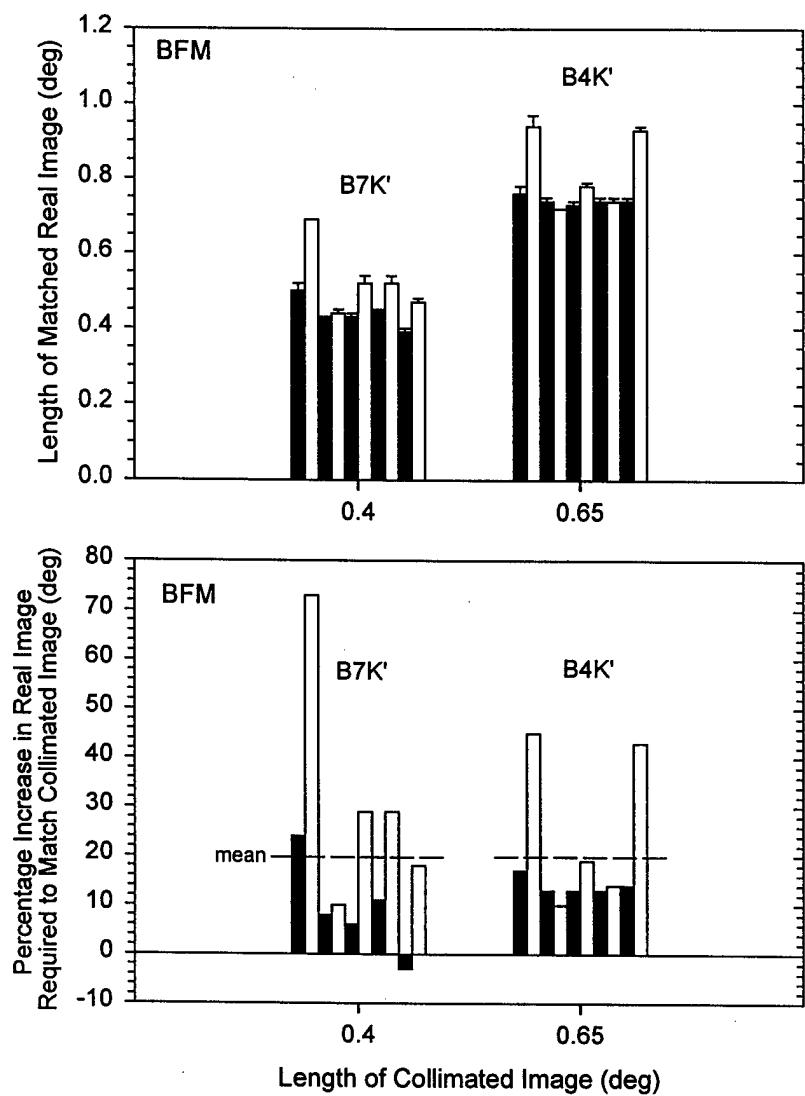


Fig. 4. Data for Each Observer Obtained at Each of the Two BFM Distances.